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FEDERAL COMMUNICATIONS COMMISSION  
INTERNATIONAL BUREAU

Satellite and Radiocommunication Division  
Satellite Policy Branch

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JUN 3 1996

To: Mr. William F. Caton, Acting Secretary

Date: June 3, 1996

From: Giselle Gomez

Re: Ex Parte presentation  
CC Docket No. 92-297

Docket File Copy Original  
FEDERAL COMMUNICATIONS COMMISSION  
OFFICE OF SECRETARIAL SUPPORT

This will serve to indicate that on May 30, 1996 representatives of the International Bureau and the Wireless Telecommunications Bureau met with participants listed in Attachment A to this memorandum to discuss inter-service sharing issues in the above-referenced proceeding.

The attached documents formed a basis for discussion.

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TI / LM mtg 5/30/96 'ATTACHMENT A'

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GEO Earth Station Interference into LMDS Return Links  
by Texas Instruments

## 1. Introduction and Objective

This analysis evaluates the spectrum and area sharing between GEO earth station uplink transmission and LMDS return link circuits. LMDS omnidirectional hubs receive the subscriber return link and are susceptible to interference from earth station transmissions in the same area on the same frequency. The interference results from earth station transmitted power in the sidelobe that may be received at the hub operating at the same frequency. The separation between hubs and earth stations to minimize interference is examined.

## 2. Parameters

Following are the system parameters of interest for return link analysis for the satellite gateway station and the LMDS return link.

LMDS Subscriber to Hub Parameters

Parameter	Units	Continuous Mode	Burst Mode
Modulation Type		DQPSK	DQPSK
Multiple Access Method		TDM/FDM	TDMA/FDM
Data Rate	Mbps	2.4	2.6
Bandwidth per Carrier	MHz	2.5	2.5
Minimum Subscriber to Hub Range	Km	0.1	0.1
Maximum Subscriber to Hub Range	Km	5.0	5.0
Maximum Transmit Power	dBW	-10	-10
Nominal Clear Sky Transmit Power	dBW	-20	-20
Subscriber Antenna Gain	dBi	35	35
Hub Receiver Antenna Gain	dBi	15	15
Hub Receiver Noise Figure	dB	6.5	6.5
Required C/(N+I) for $10^{-9}$ BER	dB	10.8	12.5
Total System C/I <sub>TOTAL</sub>	dB	15.2	15.5

### Lockeed-Martin Gateway Link Parameters

Parameter	Units	Uplink Clear Sky	Uplink Rain
Modulation Type		QPSK	QPSK
Multiple Access Method		TDMA	TDMA
Number of TDMA Stations		?	?
Data Rate	Mbps	310	310
Bandwidth per Carrier	MHz	250	250
Orbit Height	Km	35,780	35,780
Elevation Angle	degrees	35-45	35-45
Transmit Power (2.4 M Gateway)	Watts	15	200
Earth Station Antenna Gain*	dBi	55.6	55.6
EIRP	dBWi	66.7	77.9
Satellite Antenna Gain (-3dB)**	dBi	37.7	37.7
Inter-System C/I	dB	22	22
Intra-System C/I	dB	22	22
Total Received C/(N+I)	dB	9.9	10.0
Required Eb/No	dB	7.7	7.7

\* Sidelobe gain of gateway per FCC Part 25 para 25.209, is  $32 - 25 \log \theta$  dBi in the plane of the horizon.

\*\* Half Power Beamwidth estimated  $1.6^\circ$  degrees

$\approx 40^\circ$

### 3. Calculations

#### 3.1 LMDS Return Link Bit Error Rate

A bit error rate of  $10^{-9}$  is desired for the LMDS subscriber return link. Pi/4-QPSK is used for the return link modulation in a bandwidth of 2.5 MHz.

#### 3.2 Required C/(N+I)

##### Forward Error Correction and C/(N+I) Required

	Continuous Mode	Burst Mode
Reed-Solomon	85,69,8	36,28,4
Viterbi	Rate 7/8	none
Eb/(No+Io) total, theory	8.3 dB	10.0 dB
Implementation*	2.5 dB	2.5 dB
Required Eb/(No+Io) total	10.8 dB	12.5 dB

\* Includes 1.5 dB for frequency aging error.

### LMDS Internal-Interference Budget

Source	Io/Eb	power
Crosspolarization Isolation*	-20 dB	.01
Adjacent Channel Interference	-20 dB	.01
Transmit-Receive Isolation	-25 dB	.0032
Adjacent Node CPE Interference	-30dB	.001
Total Internal Interference	-16.2 dB	.0242

\* Includes 5 dB for rain depolarization and power control tolerance

### 3.3 External Interference Limit

A total (internal and external) interference degradation of 3.0 dB is budgeted. The  $C/(N+I_T) = C/N - 3.0$ .

$$\begin{array}{ll} \text{Continuous Mode } C/N & = 10.8 + 3 = 13.8 \text{ dB} \\ \text{Burst Mode } C/N & = 12.5 + 3 = 15.5 \text{ dB} \end{array}$$

For the C/N and C/(N+I) above, the "normalized" total interference is  $I_T = I_{INT} + I_{EXT}$  as summarized below.

Operation	Continuous Mode		Burst Mode	
	dB	power	dB	power
A. Required ( $N + I_T$ ) for BER $10^{-3}$	-10.8	0.0832	-12.5	0.0562
B. Required (N)	-13.8	0.0417	-15.5	0.0282
C. Allocated ( $I_T$ ) {A-B}		0.0415		0.0280
D. Internal Interference	-16.2	0.0242	-16.2	0.0242
E. External Interference {C-D}		0.0173		0.0038
F. External Interference (dB) $I_{ext}$	-17.6		-24.2	

An external interference of  $Eb/Io_{EXT}$  of 24.2 dB is required.

### 3.4 Receiver Signal and Interference Level

Receiver noise floor for a 6.5 dB noise figure is -197.5 dBW/Hz.

Parameter	Units	Continuous Mode	Burst Mode
Receiver Noise ( $No$ )	dBW/Hz	-197.5	-197.5
Required Eb/No	dB	13.8	15.5
Received Signal (Eb)	dBW/bit	-183.7	-182.5
External ( $Io_{EXT}/Eb$ )	dB	- 17.6	- 24.2
External Interference ( $Io_{EXT}$ )	dBW/Hz	-201.3	-206.2

### 3.5 Distance from Earth Station

For clear sky propagation, the required separation between the earth station and the hub is calculated. A satellite elevation of 40 degrees is used.

Parameter	Units	Continuous Mode	Burst Mode
Earth Station TX Power (15 watts)	dBW	+11.7	+11.7
Sidelobe Gain (32 + 25 log (40))	dBi	- 8.0	- 8.0
EIRP at 40 degrees	dBWi	+ 3.7	+ 3.7
TX Bandwidth (250 MHz)	dB	84.0	84.0
EIRP Density	dBWi/Hz	- 80.3	- 80.3
Required Hub RX Interference ( $I_{o_{EXT}}$ )	dBW/Hz	-201.3	-206.2
Hub Antenna Gain	dBi	15.0	15.0
Interference at Hub Antenna (External)	dBWi/Hz	-216.3	-221.2
Required Path Loss	dB	136.0	140.9
Separation Required*	Km	5	9

\* From: Path Loss =  $32.4 + 20 \log(F_{MHz}) + 20 \log(d_{km})$

The satellite elevation angle may be lower which would increase the separation slightly.

## Power Flux Density

Following is a calculation of the power flux density at the hub antenna for interference levels calculated for GEO earth station interference levels. The received signal in terms of the power flux density and capture area is:

$$Pr = Pd A$$

The capture area in terms of power flux density is:

$$\begin{aligned} Gr &= A 4\pi/\lambda^2 \text{ and} \\ A &= Gr \lambda^2/4\pi \end{aligned}$$

$$Pr = Pd Gr \lambda^2/4\pi$$

In dB this is

$$\begin{aligned} Pr &= Pd + Gr + 20\log(2.998e8/29e9) - 10 \log (4\pi) \\ &= Pd + Gr + 50.7 \end{aligned}$$

$$Pd = Pr - Gr + 50.7$$

Using the Pr power density value for external interference in the burst mode,

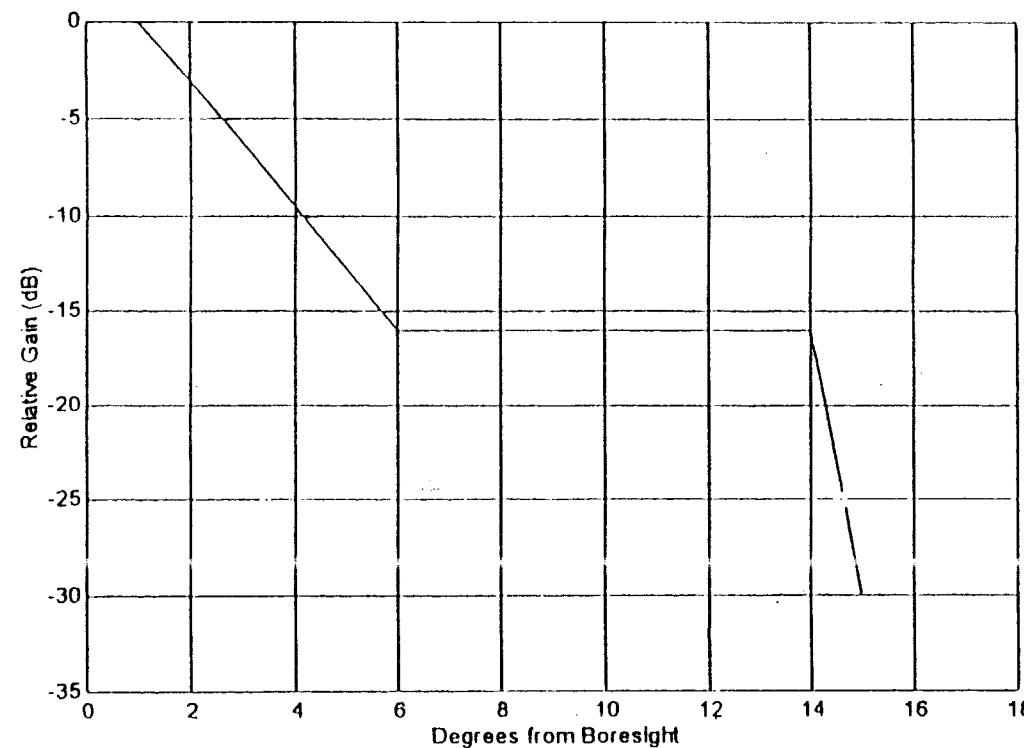
$$\begin{aligned} Pd &= -206.2 - 15 + 50.7 \\ &= -170.5 \text{ dBW/Hz} \end{aligned}$$

This density in terms of MHz is

$$\begin{aligned} Pd &= -170.6 + 60 \\ &= -110.6 \text{ dBW/m}^2/\text{MHz} \end{aligned}$$

LMDS SUBSCRIBER TRANSCEIVERS  
29.1-29.25 GHZ BAND

ANTENNA EIRP/MASK



TICPE\_L1.TXT

The name of this output file : TICPE\_L1.TXT  
 Interaction mechanism examined : CPE Interference to Lockheed GEO (Rule power, rule and mask)

The SV orbital altitude (km)	:	39551
The SV antenna HPBW (degrees)	:	1.6
The SV antenna boresight elevation angle (deg)	:	40
The SV uplink e.i.r.p. density (dBW/xHz)	:	-17.3
The CPE e.i.r.p density (dBW/xHz)	:	-46
The CPE ant. nominal look angle to HUB (deg)	:	0.343771
The LMDS cell spacing (km), within SV HPBW.	:	29
The LMDS cell spacing (km), outside SV HPBW.	:	68
The LMDS hub tower height (m).	:	30
The LMDS hub to CPE maximum range (km).	:	5
The LMDS cell spc. (km), dense swath in SV HPBW	:	5
The LMDS area ratio relative to the SV HPBW	:	1
The polarization factor between SV & LMDS (dB)	:	3
The SV sub-satellite longitude (GCD-deg)	:	0
The SV antenna aim-point longitude (GCD-deg)	:	43.8933
The sampling edge of the LMDS sites (GCD-deg)	:	53.0836

There are 3086 LMDS cells and the aggregate C/I is 33.2 dB.

There are 2008 LMDS cells within SV HPBW: C/I is 33.4 dB.

C/I for various LMDS site elev angles towards the SV

Number	Elevation angle	C/I	C/Is-up	C/Is-dn
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0	0.0 - 5.0	96.0	33.2	96.0
0	5.0 - 10.0	96.0	33.2	93.0
0	10.0 - 15.0	96.0	33.2	91.2
0	15.0 - 20.0	96.0	33.2	90.0
0	20.0 - 25.0	96.0	33.2	89.0
76	25.0 - 30.0	60.4	33.2	60.4
758	30.0 - 35.0	40.3	33.2	40.2
962	35.0 - 40.0	37.2	34.1	35.5
951	40.0 - 45.0	38.0	37.1	33.5
340	45.0 - 50.0	44.2	44.2	33.2
0	50.0 - 55.0	96.0	89.0	33.2
0	55.0 - 60.0	96.0	90.0	33.2
0	60.0 - 70.0	96.0	91.2	33.2
0	70.0 - 80.0	96.0	93.0	33.2
0	80.0 - 90.0	96.0	96.0	33.2

C/I for various satellite off-axis angles

Number	Off-axis angle	C/I	C/Is-up	C/Is-dn
760	0.0 - 0.5	36.5	33.2	36.5
1398	0.5 - 1.0	36.0	35.9	33.2
327	1.0 - 1.5	51.7	51.4	33.2
303	1.5 - 2.0	65.1	62.3	33.2
287	2.0 - 2.5	65.7	65.5	33.2
12	2.5 - 3.0	80.2	79.3	33.2
0	3.0 - 3.5	96.0	86.4	33.2
0	3.5 - 4.0	96.0	87.0	33.2
0	4.0 - 4.5	96.0	87.5	33.2
0	4.5 - 5.0	96.0	88.2	33.2
0	5.0 - 5.5	96.0	89.0	33.2
0	5.5 - 6.0	96.0	90.0	33.2
0	6.0 - 7.0	96.0	91.2	33.2
0	7.0 - 8.0	96.0	93.0	33.2
0	8.0 - 9.0	96.0	96.0	33.2

TICPE\_L2.TXT

The name of this output file : TICPE\_L2.TXT  
 Interaction mechanism examined : CPE Interference to Lockheed GEO (TI power/ant mask)  
 The SV orbital altitude (km) : 39551  
 The SV antenna HPBW (degrees) : 1.6  
 The SV antenna boresight elevation angle (deg) : 40  
 The SV uplink e.i.r.p. density (dBW/xHz) : -17.3  
 The CPE e.i.r.p density (dBW/xHz) : -50  
 The CPE ant. nominal look angle to HUB (deg) : 0.343771  
 The LMDS cell spacing (km), within SV HPBW. : 29  
 The LMDS cell spacing (km), outside SV HPBW. : 68  
 The LMDS hub tower height (n). : 30  
 The LMDS hub to CPE maximum range (km). : 5  
 The LMDS cell spc. (km), dense swath in SV HPBW: 5  
 The LMDS area ratio relative to the SV HPBW : 1  
 The polarization factor between SV & LMDS (dB) : 3  
 The SV sub-satellite longitude (GCD-deg) : 0  
 The SV antenna aim-point longitude (GCD-deg) : 43.8933  
 The sampling edge of the LMDS sites (GCD-deg) : 53.0836

There are 3086 LMDS cells and the aggregate C/I is 37.2 dB.

There are 2008 LMDS cells within SV HPBW: C/I is 37.4 dB.

C/I for various LMDS site elev angles towards the SV

Number	Elevation angle	C/I	C/Is-up	C/Is-dn
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Number	Elevation angle	C/I	C/Is-up	C/Is-dn
0	0.0 - 5.0	96.0	37.2	96.0
0	5.0 - 10.0	96.0	37.2	93.0
0	10.0 - 15.0	96.0	37.2	91.2
0	15.0 - 20.0	96.0	37.2	90.0
0	20.0 - 25.0	96.0	37.2	89.0
76	25.0 - 30.0	64.6	37.2	64.6
758	30.0 - 35.0	44.6	37.2	44.6
962	35.0 - 40.0	41.7	38.0	39.9
951	40.0 - 45.0	41.4	40.5	37.6
340	45.0 - 50.0	47.6	47.6	37.2
0	50.0 - 55.0	96.0	89.0	37.2
0	55.0 - 60.0	96.0	90.0	37.2
0	60.0 - 70.0	96.0	91.2	37.2
0	70.0 - 80.0	96.0	93.0	37.2
0	80.0 - 90.0	96.0	96.0	37.2

C/I for various satellite off-axis angles

Number	Off-axis angle	C/I	C/Is-up	C/Is-dn
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Number	Off-axis angle	C/I	C/Is-up	C/Is-dn
760	0.0 - 0.5	40.6	37.2	40.6
1398	0.5 - 1.0	39.9	39.8	37.2
327	1.0 - 1.5	55.5	55.2	37.2
303	1.5 - 2.0	69.3	66.3	37.2
287	2.0 - 2.5	69.6	69.4	37.2
12	2.5 - 3.0	84.2	82.2	37.2
0	3.0 - 3.5	96.0	86.4	37.2
0	3.5 - 4.0	96.0	87.0	37.2
0	4.0 - 4.5	96.0	87.5	37.2
0	4.5 - 5.0	96.0	88.2	37.2
0	5.0 - 5.5	96.0	89.0	37.2
0	5.5 - 6.0	96.0	90.0	37.2
0	6.0 - 7.0	96.0	91.2	37.2
0	7.0 - 8.0	96.0	93.0	37.2
0	8.0 - 9.0	96.0	96.0	37.2